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Study of Optical Properties of X-ray Sources
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This report summarizes work during the period 1 Jan. - 31 Aug. 1974 in five areas: observations of HZ Her, observations of binary X-ray sources with supergiant primaries, observations of Cyg X-3, analysis and publication of earlier simultaneous optical and X-ray observations, and preparations for optical coverage of the 1974 lunar occultations of the Crab Nebula.

I. HZ Herculis (= Her X-1)

Observations with a dual-channel photometer which were made of HZ Her during 24 August - 3 September (reported in the Semi-Annual Report for the period 1 July - 31 December 1973) were reduced and published in the Astrophysical Journal (Letters), 190, L63 (1974). This analysis reveals non-periodic flickering on a time scale of 15-300 seconds in the HZ Her system, the amplitude and frequency distribution of the flickering appears to be correlated with the orbital phase. Maximum flickering occurs at $\phi = 0.5$ (maximum light) and this rules out models for the HZ Her system which invoke optical emission from a hot-spot in an accretion disc surrounding the X-ray source to account for the "third light" observed in the system. These results are consistent with a model proposed by S.C. Perronod and G. A. Shields (1974) in which the "third light" is caused by electron scattering of radiation from the hot side of HZ Her in a solar wind which feeds the mass accretion.

We have obtained additional photometry of HZ Her throughout the summer to confirm our results. These data are being analyzed. We are also going back through older data to see if a correlation

can be established between HeI line strength and optical brightness which would support the Perronod-Shields model.

An attempt to provide optical coverage of HZ Her simultaneous with X-ray observations by the NRL group (S. Shulman) which was looking for soft ($\frac{1}{4}$ keV) X-ray flickering was a failure due to cloudy weather. However, coverage was obtained before and after the launch day of 6 September 1973 (CDT) and this data may prove to be of some use.

B. Supergiant Primary X-ray Binary Systems

A collection of spectroscopic data (high-dispersion coude plates) on X-ray sources identified with binary systems having a supergiant primary was completed with plates obtained of HD 77581 (= 3U 0900-40) in January 1974 with the 2.1 m (82 inch) telescope and coude spectrograph at McDonald Observatory. A study of these spectra for rotational anomalies is in progress. C. Wheeler who recently joined the University of Texas Astronomy Department has made and is continuing a theoretical study of rotation and eccentricity in these systems. His models will serve as a guide to this study.

A preliminary observing schedule was prepared and submitted for UV observations of these systems using the IUE satellite.

C. Cyg. X-3

No significant detection of $\lambda = 2$ mm flux was detected from Cyg X-3 during this period. Effort has concentrated on design and construction of a computer telescope control and data acquisition system so that monitoring of Cyg X-3 can be efficiently incorporated into the other program at the Texas millimeter wave antenna. This

effort is nearly over. We anticipate regular monitoring to begin in October 1974 and to be able to determine in real time whether Cyg X-3 has been detected or not in a given observation. Unfortunately, this schedule is too late for the "World-Wide Cyg X-3 Watch" of September 1974.

D. Sco X-1 (and other sources)

Early simultaneous optical and X-ray observations of Sco X-1 and Cyg X-2 and other sources) by a number of optical observers and X-ray workers using Uhuru, OSO, and Apollo satellites is just beginning to be submitted for publication. "The X-ray, Optical, and Radio Behavior of Scorpius X-1: the 1971 Coordinated Observations," Brodt, H.V., Braes, L.L.E., Forman, W., Hesser, J.E., Hiltner, W.A., Hjellming, R., Kellogg, E., Kunkel, W.E., Miley, G.K. Moore, G., Pel, J.W., Thomas, J., Vanden Bout, P., Wade, C., and Warner, B. (1974) has been submitted to the Astrophysical Journal for publication. Although the data reveal no startling new behavior, optical to X-ray correlations are present whereas X-ray/optical to radio correlations are absent.

E. The Crab Nebula

Plans have been made to help support X-ray observations of the occultations of the Crab Nebula on 3 November and 27 December. X-ray observers will be studying the size of the X-ray emitting region at various energies and searching for bright emission knots. We plan to obtain direct photographs of the Crab Nebula on IIaD emulsions with a Schott OG 4 filter on approximately four nights at intervals of 30 days during October - January. These photographs will give a picture of the Crab in continuum radiation of $X = 530$ to 650 m ($5300 - 6500 \text{ \AA}$) and they will be studied for the presence and motion

of wisp structure near the pulsar. This work is being done with Dr. Peter Shelus of the Astronomy Department, U.T. Austin and the contact person for coordinating with X-ray observers is Dr. Robert Novick of Columbia University.

REFERENCES

Perrenod, S.C., and Shields, G.A. (1974), "X-ray Heating and the Optical Light Curve of HZ Herculis", preprint (submitted to Ap.J.).